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The impact of M&A activity on innovation in the pharmaceutical industry

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Abstract

The present Work Project discusses the answer from Deloitte to a proposal raised by the European Commission on Mergers and acquisitions and its impact on innovation in the pharmaceutical industry. A theoretical approach on the subject was performed through a literature review and the foundation of a statistical approach was laid by developing a methodology for the study as well as defining statistical parameters suited for the research.

Objectives for the organisation

In September 2017, I joined Deloitte Belgium as an intern in the financial advisory department. I was mainly working inside the valuation team inside the corporate finance business unit. During my time in the company, I was supervised by Stijn de Nijs, manager inside the valuation team. Throughout my first months in the company, I was mainly involved in answering a request for Proposal demanded by the European commission and working on different smaller projects involving calculation of Wacc's or valuation of companies. The title of the proposal was "The Study on the Impact of Mergers and Acquisitions on Innovation in the Pharmaceutical Sector". In order to answer the RFP from the EC, I was assigned to a team composed of members from Deloitte Monitor[1] and Deloitte consulting London.

Mergers and Acquisitions of a certain size, which potentially affect members of the European Union must be approved by the European commission under the Council Regulation.[2] The examination of proposed mergers by the European commission (EC) aims to inhibit harmful effects on competition and price in order to protect consumer interests. The merger review by the EC is prospective in nature and ambitions to prevent mergers that would reduce competition in the industry and would deprive customers with the benefits of the competition.

[1] Deloitte Monitor is the Monitor Deloitte is the multinational strategy consulting practice of Deloitte Consulting. Monitor Deloitte specializes in providing strategy consultation services to the senior management of major organizations and governments.

[2] Council Regulation (EC) No 139/2004 of 20 January 2004 on the control of concentrations between undertakings (the EC Merger Regulation)
http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:024:0001:0022:en:PDF

A few studies already have examined how M&A activity could have an impact on innovation in the pharmaceutical industry. The objective of this study for the EC is to complement previous studies on the subject by using new innovation indicators relating the impact of M&A through a statistical analysis by answering the following research question (RQ):

RQ: What statistical parameters can be used as indicators to measure innovation inside pharmaceutical companies?

The aim of the research is first to analyse the impact of M&A on innovation in general terms as previous studies have already covered but also specifically on medicinal product development and launch. Secondly, an analysis should be conducted of how particular mergers in the pharmaceutical sector have had an impact on innovation and medicinal product development. This analysis should be conducted through different illustrations of case studies on specific mergers aiming to provide validations to the former statistical analysis.[3]

Scope of the study

The study is directed towards M&A deals with European relevance (at least one M&A entity commercialising medicinal products in the EEA) and or having R&D capabilities worldwide aiming to launch medicinal products in the EEA[4].

The pharmaceutical companies present in the sample must verify the following conditions:

- The manufacturer of pharmaceutical products must be innovative in nature, generic medicinal products manufacturers should be excluded from the sample

[3] European Commission. (2017). CALL FOR TENDERS: Study on the impact of mergers and acquisitions on innovation in the pharmaceutical sector. Retrieved from https://etendering.ted.europa.eu/cft/cft-questions.html;eTenderingPublic=IZ-3A4TZ9TOL_ywDtIvt7azA3uDR29kWHq0kos83vwMOgWevt-eX!-1127343784?cftId=2798

[4] EEA stands for European Economic Area. Created in 1994, the EEA combines countries of the EU and member countries of EFTA and is composed of Austria, Belgium, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.Bulgaria, Czech Republic, Cyprus, Denmark, Estonia,Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania,

- The company must produce prescription medicinal products (over the counter products must be excluded)
- Transactions between the companies must have taken place between 2010 and 2013
- Transactions must have a deal value above 50 million euro
- The sample must have a minimum size of 100 companies.

Analysis methodology

For the elaboration of our tender to the proposal, one of my task was to compile a list of relevant statistical parameters that could be of interest for the study. Studying the impact of M&A on innovation, it important to identify the right indicators that M&A deals would influence the most. In order to gather that list, my first idea was to separate each potential indicator according to those tree categories of variables:

- R&D resource indicators
- Pipeline progress indicators
- Market and financial performance indicators

After having established this list, first I had to explain the rationale behind the inclusion of each potential statistical variable. Secondly, I had to find the potential sources for extracting those statistical indicators by researching in the different databases if it was possible to extract relevant data able to express those parameters.

Finally, I organized the indicators according to four categories by including an additional group covering M&A deal specific indicators. This additional group was included since variables explaining the rationale of the form of the deal should also have a substantial impact on innovation. For example, the relative size of the deal premium paid by the acquirer could be a significant indicator for spurring innovation inside the new entity since a company might be willing to pay more for a target where they believe they can achieve synergies, ultimately leading to innovation.

Table 1: Examples of R&D resource indicators

R&D resource indicators	Rationale	Source
R&D spending	Definition: R&D spending is the annual amount (expressed in $ million) a firm devotes to research and development. R&D spending should have a direct impact on innovation. Rationale: Since innovation is the output of R&D a measure of R&D expenditure will likely have a positive effect on innovation	Bloomberg, Annual reports, EU R&D Scoreboard
R&D intensity	Definition: R&D intensity is total R&D expenditure divided by total revenue Rationale: In general, R&D is seen as a main driver of societal and business innovation. Hence, measuring R&D intensity would have a positive relationship with innovation.	EU R&D Scoreboard, Annual reports, Bloomberg

Table 2: Examples of pipeline progress indicators

Pipeline progress indicators	Rationale	Source
Number of medicinal products in various clinical development phases	Definition: The sum of all chemical/biological entities in the different development phases of the R&D process. Rationale: An increase in the number of medicinal products in the various clinical development phases after an M&A activity would indicate that the company is bringing more products into development and hence has a positive impact on innovation.	Annual reports Other sources from the grey literature will also be considered.
Number of discontinued Programs in view of related clinical trial results	Definition: The number of programs that are stopped because of unsuccessful results during clinical trials. Rationale: there might be a negative relationship between the number of discontinued programs and innovation. A high number of discontinued programs can represent a lack of resources and lead to a lack of innovation	Annual reports Other sources from the grey literature will also be considered.
Number of compounds in the preclinical stage / discovery phase (Stage 0/I)	Definition: The amount of compounds that a company has in stage 0 or 1 of research. Rationale: An increase in the number of compounds in the preclinical stage would be beneficial because it shows an inflow of newly developed compounds	Annual reports Other sources from the grey literature will also be considered.
Number of compounds in Stage II	Definition: total amount of chemical/biological entities that are in stage II of development Rationale: An increase in the number of compounds in the preclinical stage would be beneficial because it shows an inflow of newly developed compounds graduating from stage I	Annual reports Other sources from the grey literature will also be considered.
Number of compounds in Stage III	Definition: total amount of chemical/biological entities that are in stage III of development Rationale: An increase in the number of compounds in the preclinical stage would be beneficial because it shows an inflow of newly developed compounds graduating from stage II	Annual reports Other sources from the grey literature will also be considered.

Progress in pipelines	Definition: Total amount of molecules that progressed one stage including new entrants in the pre-clinical stage (stage 0) Rationale: When compounds move through the different stages, it means that the chance of it resulting in a real treatment rises. A higher number represents more innovation.	Annual reports Other sources from the grey literature will also be considered.

Table 3: Examples of market and financial performance indicators

Financial performance indicators	Rationale	Source
EBITDA	Definition: EBITDA is all earnings a company receives before taxes over a year. Rationale: EBITDA can be a proxy for firm size. Firms with large revenues will likely be more prepared for M&A activity.	Bloomberg Other sources will also be considered as Bloomberg is set for quoted companies.
Solvency ratio	Definition: solvency ratio measures the ability of a company to meet its long term debts. Calculated as followed: $\frac{\text{After Tax Net Profit} + \text{Depreciation}}{\text{Total liabilities}}$ Rationale: This ratio can be used as a proxy of the financial health of a company. Firms with high solvency ratio are more likely to have a positive impact on innovation. While firms with low solvency ratio, which can indicate a high level of leverage are more likely to decrease their R&D intensity substantially (Hall, (1990)[5].	Bloomberg Other sources will also be considered as Bloomberg is set for quoted companies.
Quick Ratio	Definition: it is the liquidity ratio of a company and is calculated as: $\frac{\text{Cash} + \text{Accounts Receivable}}{\text{Current liabilities}}$ Rationale: Quick ratio has a positive influence on R&D investment. Indeed, if a company faces a financial risk, it will be more passive in R&D investment due to its financial difficulties (Lee & Choi,	Bloomberg Other sources will also be considered as Bloomberg is set for quoted companies.

[5] Hall, B. (1999): Mergers and R&D revisited, mimeo

	2015)[6]. Therefore, quick ratio can have a substantial influence on R&D and innovation.	
Number of employees	Definition: Number of person currently employed by the company. Rationale: The number of employees can be used as proxy for firm size. Firm size can have a substantial impact on innovation as large firms have more knowledge available that fuels innovation.	Global data EU R&D Scoreboard Other
Market capitalization	Definition: Market capitalization is the market perception of the full value of the company. Rationale: It is the most simplified way to calculate a company's size and value. Where a higher value means that investors are expecting higher revenues in the future and likely also more innovation.	Bloomberg Other sources will also be considered as Bloomberg is set for quoted companies.
DEBT/ Asset	Definition: The debt to total assets ratio is an indicator of financial leverage. The debt to total assets ratio is calculated by dividing a corporation's total liabilities by its total assets. Rationale: Financial leverage should have an impact on innovation and R&D investment as companies are more likely to look to finance themselves through equity because of its more relaxing financial constraints (Chang & Song, (2014). [7]	Bloomberg Other sources will also be considered as Bloomberg is set for quoted companies.
Number of therapeutic areas the firm is active in	Definition: The number of therapeutic areas a company invests in. Rationale: A high number of therapeutic areas in which a firm invests might have an impact on the R&D output as a firm specializing in a specific therapeutic area might have a competitive advantage in that area and	Company reports
Tobin's q	Definition: the inverse of the Market to Book ratio (Tobin's q = Market value/ Book value)	Bloomberg Other sources will also be considered as Bloomberg is set for quoted companies.

[6] Lee, M., & Choi, M. (2015). The Determinants of Research and Development Investment in the Pharmaceutical Industry: Focus on Financial Structures. Osong Public Health and Research Perspectives, 6(5), 302-309. doi:10.1016/j.phrp.2015.10.013
[7] Chang, H., & Song, F. (2014). R&D Investment and Capital Structure. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.640.203&rep=rep1&type=p

	Rationale: Tobins q measures the market value compared to the book value, this means it is highly sensitive to changes in expected future cash flows that could indicate future patent expiry.	

Table 4: Examples of M&A indicators

M&A indicators	Rationale	Source
Deal size in mn	Definition: The size of the transaction (Enterprise value) in $ million. Rationale: Larger deals can have bigger consequences for innovation since firms would likely find it more rewarding to invest in more innovative firms.	Mergermarket Global Data
Relative deal size: enterprise value expressed as multiples of EBITDA, EBIT and revenue	Definition: Deal size divided by EBITDA, EBIT and Revenue Rationale: this will allow expressing the relative price paid for various companies cotrolling for their size	Mergermarket
Deal type	Definition: The deal can be classified under Joint Venture, Acquisition, Merger, Strategic alliance, divestment or licensing. Rationale: The type of deal can have a substantial impact on innovation as in a strategic alliance synergies may realise faster than in a proper merger.	Mergermarket Global Data
Deal geography	Definition: Whether the merger is between two companies from different countries or from the same market. Rationale: Deal geography might have an impact on innovation as a cross boarder deal might be pursued to have access to a new market or knowledge, at the same time cross border deals might bring additional managerial problems that could hamper innovation.	Mergermarket Global Data
Premium paid	Definition: The excess value the acquirer pays to the owners of the company compared to the current market value. Rationale: Since firms are willing to pay more for more innovative companies, if the premium is very high the acquirer might see a high amount of potential synergies.	Mergermarket Global Data

In order to answer the research question and estimate what statistical parameters can be used as indicators to measure innovation inside pharmaceutical companies, a multiple linear regression model was built. The model is explained in the results sections of this paper. In conjunction with the model, statistical tests were performed aiming to analyse the different independent variables.

In addition to the statistical analysis, the proposal requires an in depth analyse of at least four mergers in the pharmaceutical sector in order to illustrate the effect of M&A on innovation for relevant companies. This case study approach enables to differentiate the impact from M&A from other factors that could influence innovation. Those case studies would serve as a validation of the results from the statistical analysis.

For the elaboration of the proposal, I was asked to research, analyse and select four cases studies that could be of interest. After the selection, I had to make a summary of the cases by explaining the motives of the companies involved behind the merger, raising the competition concerns and explain why the cases are of interest for the proposal. In the proposed solution for the organisation based on the literature review section of this research, you can find a summary of the different case studies that were selected.

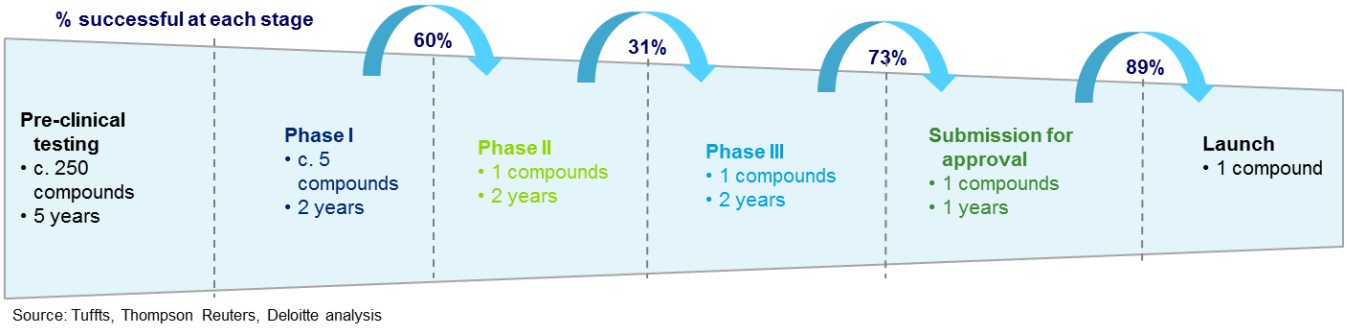
Literature review

The pharmaceutical business model relies on innovation. Indeed, pharmaceutical companies have a business model that relies on a steady stream of new products reaching the market, making innovation of the utmost importance. According to Deloitte's annual 'Measuring the Return from Pharmaceutical Innovation' report[8], since 2010 the 12 top pharmaceutical companies (defined by spend on research and development) have launched 233 products with projected total revenues of $1,538 billion. Over the same

[8] Taylor K, Stockbridge M, Shah S. (2016). Balancing the R&D equation: measuring the return from pharmaceutical innovation. https://www2.deloitte.com/uk/en/pages/life-sciences-and-healthcare/articles/measuring-return-from-pharmaceutical-innovation.html.

period the R&D divisions of these companies have progressed 376 assets into late-stage pipelines with total forecast sales of $1,697 billon.

Figure 1: Attrition rate per clinical trial phase



[9]

However, almost every year, we have seen declining returns on company investment in innovation[10]. In the latest report, projected returns are at their lowest at 3.7 percent, compared to the original high of 10.2 percent in 2010. While the total number of pipeline assets has remained relatively constant the value of these assets has declined significantly. This has led to a situation in which there are blockbuster costs without balancing blockbuster revenues – average peak sales per asset has declined from $816 million in 2010 to $394 million in 2016.

It is well documented that changes in the way the pharmaceutical industry operates are likely behind this trend[1]. Regulatory, health system and political environments are all exerting unprecedented pressures on companies as is the increasingly specialized nature of drug discovery and development.

The Deloitte 'R&D leaders' report[11] confirms that key drivers influencing life science R&D priorities are:

[9] Thomas, D. W., Burns, J., Audette, J., Carroll, A., Dow-Hygelund, C., & Hay, M. (2016). Clinical Development Success Rates 2006-2015. Retrieved from Biotechnology Innovation Organization website: https://www.bio.org/sites/default/files/Clinical%20Development%20Success%20Rates%202006-2015%20-%20BIO,%20Biomedtracker,%20Amplion%202016.pdf

[10] Taylor K, Stockbridge M, Shah S. (2016). Balancing the R&D equation: measuring the return from pharmaeutical innovation. https://www2.deloitte.com/uk/en/pages/life-sciences-and-healthcare/articles/measuring-return-from-pharmaceutical-innovation.html.

[11] Taylor K., Terry C. (2017). 2017 Pharmaceutical R&D leader survey Innovating to survive, collaborating to thrive. https://www2.deloitte.com/uk/en/pages/life-sciences-and-healthcare/articles/pharmaceutical-r-and-d-leader-survey.html

- Rapid shifts in regulatory and payer environments
- The generation of new insight derived from Real World Evidence (RWE)
- Pressures to reduce time to market
- Ongoing re-evaluation of the portfolio composition in light of competitor activities and therapeutic advances.

Externalization strategies are also being adopted to respond to market challenges. Indeed, R&D leaders are turning to externalization strategies when responding to market challenges and innovation competition. There is a strong belief that looking externally will help gain access to talent and cutting edge technologies, consolidate in specific therapy areas and improve development success rates. Leaders are particularly interested in non-horizontal deals in e.g. digital, IT and data analysis to develop devices or applications to collect patient data and enable data management and analysis. Clinical partnerships for designing and conducting clinical trials also remain a high priority.

This trend is particularly true when considering early stage innovation – discovery and phase 1 development – where activity is increasingly moving towards a network of smaller, highly specialized start-up & academic organizations, and away from big pharma.

"we are changing to become more extroverted in early stage research while development will become more introverted by harnessing internal knowledge to use as a competitive edge and to become less dependent on CROs who have little to loose from failing" – Chief Scientific Officer

However, M&A is just one element of an externalization strategy. Hence, executing an externalization strategy is not limited to M&A. Joint ventures and collaborations are increasingly common alternatives. The popularity of M&A has declined in recent years, perhaps due to the often inflated prices of potential targets. According to Deloitte's annual M&A index[12], which tracked $3.2 trillion worth of M&A activity in 2016 across multiple sectors and geographies; pharmaceutical M&A volume remains strong but the

[12] Macmillan I., Prakash S. (2017). The Deloitte M&A Index 2017: Dealing with the future. https://www2.deloitte.com/uk/en/pages/financial-advisory/articles/deloitte-m-and-a-index.html

values showed a sharp decline in 2016 – totaling $75 billion, down from $200 billion in 2015; only three so called ‘mega deals’ were announced in 2016, compared to eight in 2015.

A similar trend can be observed when considering the origin of late stage pipeline value in Deloitte R&D report. Since 2013, there has been a steady decrease in the proportion of projected late-stage pipeline revenue derived from externally sourced assets, a trend that accelerated in 2016 as the last of the assets acquired as part of large-scale M&A in the late 2000s launch.

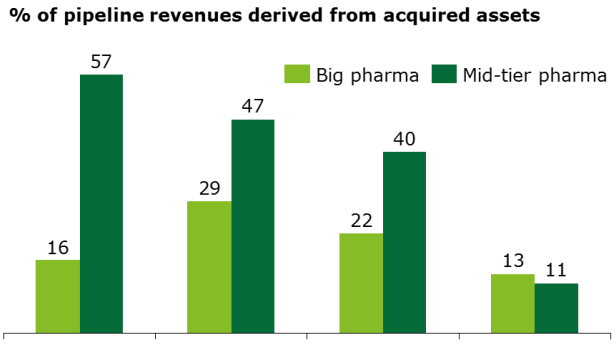
Therefore, it will become increasingly important to understand the impact of M&A on innovation.

We believe that big pharma companies will increasingly look to M&A to replenish pipelines and make up for their inability to foster internal innovation. Indeed, this may have already become a reality in Europe which in Deloitte’s ’M&A index’ report[3] was the only region that saw an uptick in pharma M&A deals in 2016 vs. 2015 – with France being the most active target country.

Consequently, it is timely to gain a better understanding of the extent M&A impacts the broader innovation environment to ensure patients and society continue to benefit from advances in medicine.

The relationship between M&A and innovation is complex. Deloitte has explored elements of this already as it relates to individual pharmaceutical companies. For example, data from its annual R&D report suggests that, compared to big pharma, mid-tier pharmaceutical companies have a greater proportion of late stage pipeline value sourced via acquisitions and are more likely to have a higher rate of return on their investment into innovation.

Figure 2: Share of revenue derived from acquired assets



% return on investment	2013	2014	2015	2016
Big pharma	4.8	5.5	4.2	3.7
Mid-tier pharma	**17.4**	**17.7**	**16.1**	**9.9**

[13]

However, a broader analysis by Deloitte contrasting 1,621 licensing deals, 69 M&A deals and 9 joint ventures between 2007-12 found that on a per asset level, M&A deals were associated with a lower probability of launch (12% vs. 22% for licensing and 56% for joint ventures) suggesting there are many different factors at play.

A relatively large body of academic literature has attempted to explore the relationship between M&A and innovation[14]. From a business perspective, M&A are often considered to be attractive as they remove duplication, reduce costs and produce synergies resulting in economies of scale/scope or other financial gains[15]. Examples of this include the sharing of duplicated departments like marketing and human resources to profit from economies of scale, the merging of a sales force to benefit from the economies of scope and the recently failed Pfizer/Allergan merger where tax gains were possible. Another financial reason to pursue a merger is to fill the pipeline with more products, providing the firm with more certainty on sustainable

[13]Taylor K, Stockbridge M, Shah S. (2016). Balancing the R&D equation: measuring the return from pharmaeutical innovation. https://www2.deloitte.com/uk/en/pages/life-sciences-and-healthcare/articles/measuring-return-from-pharmaceutical-innovation.html.
[14] Schulz, N. (2007). Review on the literature of mergers on innovation.
[15] Mittra, J. (2007). Life science innovation and the restructuring of the pharmaceutical industry: Merger, acquisition and strategic alliance behaviour of large firms. *Technology Analysis & Strategic Management*, *19*(3), 279-301.

revenue generation in the future. These deals also include mergers where the firm substantially deviates from their specialization, bringing them into new treatment areas.

LaMattina (2011)[16] presented how early-stage R&D could be slowed as a result of M&A given the time some fundamental processes may take to align, such as IT platforms, data handling or adverse event monitoring systems. Industry consolidation is argued also to have resulted in less competition and less investment in R&D.

Bronwyn Hall (1988)[17] finds that there is no difference in pre- and post-M&A R&D performance in firms who are involved in merger. However, for firms with the highest propensity to merge, those that did merge experienced more rapid post-M&A growth that those that did not merge. Martynova et al. (2006) suggested that the acquirer's leverage prior to takeover seems to have no impact on the post-M&A performance of the combined firm[18,19]. They also concluded that acquisitions of relatively large targets result in better profitability of the combined firm subsequent to the takeover, whereas acquisitions of a small target lead to a profitability decline.

Danzon et al. (2007)[20] analyzed the post-M&A performance of the pharmaceutical industry on the firm level for the period 1988-2000. They splitted the sample into large and small firms; and first estimated propensity scores for being involved in a merger. They found that large firm mergers are connected to expiring drug patents, while small firms' propensity to be involved in a merger (target) is connected to financial distress. The impact of mergers on R&D was only one of their performance indicators. R&D was measured as R&D investments. Controlling for the propensity score large firms that merged did not show significantly different R&D activities up to 3 years after the merger compared to firms that did not merge.

[16] LaMattina, J. L. (2011). The impact of mergers on pharmaceutical R&D. *Nature reviews. Drug discovery*, *10(8)*, 559.
[17] Hall, B. H. (1988). The effect of takeover activity on corporate research and development. In *Corporate takeovers: Causes and consequences* (pp. 69-100). University of Chicago Press.
[18] Martynova, M., Oosting, S., & Renneboog, L. (2006). The long-term operating performance of European mergers and acquisitions.
[19] Tjandrawinata, R. R., & Simanjuntak, D. G. (2012). The impact of mergers and acquisitions in research-based pharmaceutical companies on productivity.
[20] Danzon, P. M., Epstein, A., & Nicholson, S. (2007). Mergers and acquisitions in the pharmaceutical and biotech industries. *Managerial and Decision Economics*, *28*(4-5), 307-328.

In general small firms exhibited lower R&D investment growth if they merged. Only small firms with a very high propensity score witnessed a higher R&D activity.

Frey and Hussinger (2006)[21] concentrated on the probability of being a merger target depending on the innovative performance of the firm. Hence, here it was not the impact of a merger on innovation, but on the contrary the impact of innovative performance on being involved in a merger as a target. They found that the stock of patents has a negative impact on this probability and cross-border dummy has also a negative impact, but the interaction term of the technical proximity (closeness of patent portfolios) with the cross-border dummy triggers a positive impact, while the same interaction term for domestic mergers does not.

As some firms engage in innovation in order to be acquired the causality of this relationship, however, is not clear.

Overall, drawing conclusions with certainty is a challenge because current research tends to:

- Consider narrow / crude innovation measures (e.g. R&D spending, where more targeted spending may be more beneficial than higher total spending)
- Focus on measuring innovation over a relatively short time period, which may not be reflective of the drug development timelines.
- Lack sufficient exploration of the many different nuances that could influence an innovation outcome e.g. M&A sub-groups, reason for M&A, post-M&A integration approach etc.

It will be important to consider a range of different innovation types and innovation outcomes when measuring the impact of M&A.

In addition, there is a need to segment M&A events to fully understand how different types of M&A can effect innovation.

[21] Frey, R., & Hussinger, K. (2006). *The role of technology in M&As: a firm-level comparison of cross-border and domestic deals* (No. 2006, 45). Discussion paper Series 1/Volkswirtschaftliches Forschungszentrum der Deutschen Bundesbank.

Proposed Solution for the organisation based on the literature review

Data

For the empirical analysis, several data sources have been used. Data on the deals were collected from the website MergerMarket (https://www.mergermarket.com/homepage?). The website provides a global library of public and private historical M&A transactions including fully sourced financials for the entire dataset.

The data was collected using search function of the website by narrowing our sample of transactions based on the following characteristics:

- European deals: at least one of the acquirer or the target must be active in Europe
- The transaction must have been completed between 01/01/2010 and 31/12/2013
- Deals of at least €50 Million
- Both acquiring and target companies must be primarily active in the Pharmaceutical sector and have activities in the development of new medicinal products
- The acquiring companies must be publicly traded on stock market
- The acquiring company must still be active and have not been acquired by another company after M&A event.

Based on that research and on availability of data, our treatment group consists of 46 public transactions having occurred between the 14th of January 2010 and the 9th of January 2014. The sample consists of 32 different acquiring companies that are currently active.

The research mainly relies on quantitative and secondary data, as for the 32 acquiring companies; annual data on different indicators was downloaded from a secondary source; Bloomberg. Annual figures about revenue, EBITDA, R&D expenditures and the number of employees for each of the 32 companies were extracted in USD from the database from 2010 until 2017. In order to perform the regression analysis on

which we will elaborate in the results sections, more variables specific to the acquirer's financials such as Tobin's Q ratio, Total Debt to Total assets and market capitalization; were downloaded from Bloomberg.

Our data represents a panel data as it is multi-dimension involving observations of multiples companies with the same indicators studied over multiple time periods, permitting for observation of variations over time.

Following the data collection, a data consolidation was completed by cross checking the numbers downloaded from Bloomberg and by adding figures to the missing values. Those were extracted from annual reports of the different companies of the sample.

Furthermore, annual figures for our variable indicator representing innovation; R&D intensity; were calculated using the following formula:

$$R\&D\ intensity = \frac{Turnover}{R\&D\ expenditures}$$

Turnover characterizes the total revenue in USD generated by a company during a year. R&D expenditures represent the amount of money in USD that a company allocates to research and development.

After having calculated R&D intensity, we modelled the data in order to obtain the growth in R&D intensity in the time period preceding and succeeding the main M&A event for each company. This term represents the base year on which the company completed a merger or an acquisition. For companies in our sample that took part in multiple mergers or acquisition between 2010 and 2013, we selected the year with the most significant acquisition in terms of deal value as base year for M&A event. As an example, in our treatment group; Allergan took part in 3 different acquisitions in 2011, 2012 and 2013 for a transaction price of a $ 400 mn; $4.4 bn and; $6.6 bn respectively. In that case, 2013 was taken as base year for our M&A event and is caled T0. This was the case for 4 companies in our sample. However, two of them had all of their acquisitions in the same year.

Following the data consolidation, descriptive analyses were performed for the innovation indicator variable; namely R&D intensity pre and post-merger. For every acquiring company in the sample, two years pre- (t-2) and post-mergers (t+2) figures were analyzed. For our descriptive statistics, it was of interest to analyze the variation of R&D intensity over the pre- and post- merger periods. To obtain those variations, we calculated R&D growth over the pre- M&A event from t-2 to t0 and the post M&A event from t0 to t-2 by using the compound annual growth rate formula.

Table 5: Descriptive statistics

	Label	Unit	Mean	Std. Deviation	Analysis N
Market cap t0	MC	Million US Dollars	32,829.0	47,031.9	32
Deal Value	DV	Million US Dollars	3,084.6	6,309.7	32
R&D Intensity T-2		Percentage	0.17274	0.19383	32
R&D intensity T0	RDI 0	Percentage	0.14261	0.11864	32
R&D intensity T+2		Percentage	0.14951	0.11250	32
R&D intensity growth T-2 T0	RDG0	Percentage	(0.06282)	0.27888	32
R&D intensity growth T0 -T2	RDG2	Percentage	0.13699	0.44246	32
Number of employees	EMP	Unit	26495.9	38426.2	32
Sales revenue Turnover	TUR	Million US Dollars	12147.7	17820.5	32
Sales revenue Turnover t+2		Million US Dollars	12577.3	18179.5	32
EBITDA T-2		Million US Dollars	3470.6	5670.5	32
EBITDA T0	EBI	Million US Dollars	3666.7	5602.4	32
EBITDA Margin T-2		Percentage	0.08473	0.94197	32
EBITDA margin T0	EM	Percentage	0.24310	0.14649	32
Dummy acquisition	Nac	Dummy	0.34375	0.48256	32
Tobin's Q t-2		unit	2.44068	2.77808	32
Tobin's Q T-0	TQ	unit	1.94750	0.86399	32
Tobin's Q t+2		unit	2.13350	0.81270	32
TOT DEBT to Total Assets t-2		Percentage	0.19825	0.16575	32
TOT DEBT to Total Assets t0	TD/TA	Percentage	0.24913	0.16588	32
TOT DEBT to Total Assets t+2		Percentage	0.26871	0.15113	32

Model and Estimation

Statistical Tests

In order to analyze the impact of a main M&A event on our innovation indicator: R&D intensity; we used a paired t- test to compare the growth of R&D intensity between the 2 year period preceding and following that event. Paired t- tests are used to compare two population means in two samples and where observations

in one sample can be paired with observations in another sample. In our case, we have a before and after observation on the same object: R&D intensity. [22]

The null hypothesis of our t-test is that there is no significant difference between R&D intensity growth between the 2 years periods preceding and following the M&A event. Our alternative hypothesis is that R&D intensity growth increases between the 2 years periods preceding and following the M&A event.

$$H_0: R\&D\ intensity\ growth_{t-2-t0} = R\&D\ intensity\ growth_{t0-t+2}$$

$$H_A: R\&D\ intensity\ growth_{t-2-t0} < R\&D\ intensity\ growth_{t0-t+2}$$

In addition to a paired t-test, we tested the relationship between R&D intensity two year after the M&A event with different independent M&A and company specific variables through a regression analysis.

Correlation Analysis

Table 6 represents the correlation matrix for all the variables of interest meant for the model. The negative correlation between Total Debt to Total Assets T0 and R&D intensity T+ 2 is consistent with previous findings of Hall (1990) stating that companies with low solvency ratio, which can indicate a high level of leverage are more likely to decrease their R&D intensity substantially. [23]

The correlation matrix itself is not sufficient to explain the causal relationship between the different variables as it does not take into account correlation of the different independent variables together with the dependent variable.

[22] Shier, R. (2004). Paired t test. Retrieved from http://www.statstutor.ac.uk/resources/uploaded/paired-t-test.pdf
[23] Hall, B. (1999): Mergers and R&D revisited, mimeo

Table 6: Correlation matrix of the different variables

	R&D Intensity T-2	*R&D intensity T0*	*R&D intensity T+2*	*R&D intensity growth T-2 T0*	*R&D intensity growth T0 -T2*	*Market cap t0*	*Number of employees t0*	*EBITDA Margin T-2*	*EBITDA margin T0*	*Dummy acquisition*	*Tobin's Q t-2*	*Tobin's Q T-0*	*TOT DEBT to Total Assets t-2*	*TOT DEBT to Total Assets t0*
R&D Intensity T-2	1													
R&D intensity T0	0.92	1												
R&D intensity T+2	0.54	0.75	1											
R&D intensity growth T-2 T0	-0.37	-0.05	0.27	1										
R&D intensity growth T0 -T2	-0.30	-0.25	0.26	0.13	1									
Market cap t0	-0.12	-0.05	-0.08	0.10	-0.15	1								
Number of employees t0	-0.17	-0.11	-0.15	0.15	-0.17	0.92	1							
EBITDA Margin T-2	-0.04	-0.22	-0.60	-0.44	-0.32	0.18	0.17	1						
EBITDA margin T0	-0.62	-0.57	-0.34	0.06	0.08	0.32	0.24	0.15	1					
Dummy acquisition	-0.26	-0.31	-0.25	-0.07	0.33	0.19	0.08	0.15	0.20	1				
Tobin's Q t-2	-0.19	-0.25	-0.26	-0.22	-0.24	0.05	0.07	0.10	0.04	-0.10	1			
Tobin's Q T-0	-0.07	-0.03	-0.02	-0.03	0.06	0.47	0.40	0.13	0.24	0.30	0.11	1		
TOT DEBT to Total Assets t-2	-0.35	-0.41	-0.47	-0.16	0.00	0.01	-0.02	0.22	0.29	0.19	0.14	0.29	1	
TOT DEBT to Total Assets t0	-0.31	-0.40	-0.42	-0.13	0.11	-0.04	-0.05	0.13	0.01	0.36	0.23	0.29	0.72	1

Regression analysis

The aim of this section was to lay the ground work for Deloitte and understand which variables were of interest to analyze the effect of M&A on R&D intensity. To answer the following Research Question " *What statistical parameters can be used as indicators to measure innovation inside pharmaceutical companies? "*, we have set up a multiple linear regression. It will permit to understand which among the different independent variables described in the data section, are related to the dependent variable; R&D intensity. It will help Deloitte for the elaboration of the forthcoming model that will try to infer causal relationship between the M&A and innovation.

We have set up a multilinear regression model trying to learn more about the relationship between R&D intensity at time T+2 and several independent variables that were selected based on their independent correlation coefficient with the dependent variable.

$$R\&Dintensity_{T+2} = \alpha'_0 + \beta_1 * Employee_{T0} + \beta_2 * EBITDAmargin_{T-2} + \beta_3 * EBITDA_{T0} + \beta_4 * T'sQ_{T0} + \beta_5 * TDTA_{T0} + \beta_6 * R\&Dintensity_{T0} + \beta_7 * R\&Dintensity_{T-2} + \mu_{it}$$

The result of the regression are presented on table 8 in the results section of this paper; allowing to determine the overall fit of the model and the relative contribution of each of the independent variables total variance explained.

Results

Statistical Tests

This section discusses the empirical results regarding the effects of mergers and acquisitions on the innovation activity for the acquiring firms that took part in an M&A event during the sampled period.

Table 7 shows the results of a paired t-test that compares the means for two variables, namely R&D intensity CAGR before and after the M&A event. According to the results of the paired t-test, R&D intensity CAGR for our sample has been decreasing on average by 5.93% in the two year period preceding the merger while it has been increasing by 13.16% on average in the two year period following the M&A event. The significance of the test refutes the null hypothesis that there is no difference between the R&D intensity growth for the time period preceding and following an M&A event.

Table 7: Paired Sample t test for Means of R&D intensity growth rate

	R&D intensity CAGR T-2 to T0	*R&D intensity CAGR T0 to T2*
Mean	-0.05930	0.13155
Variance	0.07623	0.20457
Observations	32	32
Pearson Correlation	0.11832	
Hypothesized Mean Difference	0.00000	
df	31.00000	
t Stat	-2.15382	
P(T<=t) one-tail	0.01957	
t Critical one-tail	1.69552	
P(T<=t) two-tail	0.03914	
t Critical two-tail	2.03951	

Those results could be explained by the fact that pharmaceuticals firm with decreasing innovative output and no products or compounds coming through their pipeline, choose to acquire targets that are being very innovative in nature, with higher R&D intensity, in order to boost their innovative production.

Table 8 illustrates the results of the paired sample t-test for mean for R&D intensity at time t-2 and t+2. As we can see, on average R&D intensity of an acquiring company decreases in the period following an acquisition. Those results are in line with a previous study by Schuz (2013) that observes a similar decline

in R&D intensity of acquiring companies in the period following an acquisition. However, our test fails to confirm this finding, as the p statistic of 0.21 does not allow to reject the null hypothesis that there is no significant difference in R&D intensity between the 2 year timespan preceding and following a merger or an acquisition.

Table 8: Paired Sample t test for Means of R&D intensity

	M&A Intensity y-2	*M&A intensity y+2*
Mean	0.17274	0.14951
Variance	0.03757	0.01266
Observations	32	32
Pearson Correlation	0.54096	
Hypothesized Mean Difference	0	
df	31	
t Stat	0.80552	
P(T<=t) one-tail	0.21333	
t Critical one-tail	1.69552	
P(T<=t) tw o-tail	0.42665	
t Critical tw o-tail	2.03951	

Regression

Results of the modelled regression in equation 1 are illustrated on table 9. According to the p value of our F test, which is statistically significant at the 5% level, our model is better at explaining the variances than a restricted model. Hence, we can reject the null hypothesis that $\beta 1=0$. In order to see if every variable uniquely predicts R&D intensity, looking at the correlation coefficient table can be useful. The adjusted R-Square tells us that 78.6% of the variation in R&D intensity at time T+2 can be attributed to the 7 variables that were chosen as predictors.

The independent variables of interest in the regression are certainly the 2 years period lag R&D intensity T0 and R&D intensity t-2 as they are both statistically significant. The negative regression coefficient of R&D intensity t-2 implies that there is a negative relationship between pre- and post- acquisition R&D intensity: higher R&D intensity prior to the M&A event is associated with lower R&D intensity after the completion of the deal. This negative relationship could be explained by the fact that bigger firms with low

R&D intensity, that need to develop or launch new innovative output, are more likely to acquire targets with a big focus on research and development and hence high R&D intensity ratio; ultimately leading to a higher R&D intensity in the period following the M&A event.

The variable EBITDA Margin T-2 is statistically significant with a correlation coefficient of -0.04 Several variables as Tobin's Q, Total debt to Total Assets and the number of employees were all statistically significant in the regression before the inclusion of R&D intensity T-2 an: d R&D intensity T0, but there explanatory power has been absorbed by the lag variable of R&D intensity The correlation coefficient of the variable number of employee t0 is 0 meaning that when taken with other variables such as R&D intensity T-2, the impact of emp disappears. This indicates the need to include a control variable in the model in order to increase its accuracy and robustness. The high standard error for both R&D intensity lag dependant variables can indicate the presence of multicollinearity in the model, affecting negatively its prediction.

Table 9: Regression results

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.913511
R Square	0.834503
Adjusted R Square	0.786233
Standard Error	0.052015
Observations	32

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	0.32742	0.04677	17.28822	0.00000
Residual	24	0.06493	0.00271		
Total	31	0.39235			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.06672	0.03065	2.17671	0.03957
Number of employees t0	0.00000	0.00000	-1.48339	0.15099
EBITDA Margin T-2	-0.04472	0.01204	-3.71389	0.00108
EBITDA T0	0.00001	0.00001	1.15407	0.25984
Tobin's Q T-0	0.01444	0.01288	1.12052	0.27358
TOT DEBT to Total Assets t0	-0.00094	0.00068	-1.39153	0.17683
R&D Intensity T-2	-0.28994	0.14863	-1.95077	0.06285
R&D intensity T0	0.98535	0.25885	3.80657	0.00086

In order to neutralise multicollinearity, R&D intensity T0 was removed from the model. As a result the standard error of the remaining independent variables of the model have decreased. Furthermore, independent variables with insignificant p values and with regression coefficient close to 0 were also removed. Table 10 displays the results of the alternative multivariable linear regression used.

Unsurprisingly, the adjusted R square has decreased and 63% of the variations of the dependant variable is now explained by the independent variables. The variable R&D intensity T-2 is still highly significant. Without the presence of the lagged variable R&D intensity T0, it is notable to see that the coefficient estimate of R&D intensity T-2 has changed of sign. The significant coefficient estimate for EBITDA margin T-2 is negatively correlated with the explained variable and could be interpreted as a decrease in EBITDA margin at time T-2 would increase slightly R&D intensity at time T2.

Table 10: Alternative regression results

Regression Statistics	
Multiple R	0.81451
R Square	0.66343
Adjusted R Square	0.62737
Standard Error	0.06867
Observations	32

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	3	0.2603	0.0868	18.3976	0.0000
Residual	28	0.1320	0.0047		
Total	31	0.3923			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.134929	0.025861	5.217545	0.000015
R&D Intensity T-2	0.264261	0.067908	3.891482	0.000562
EBITDA Margin T-2	- 0.064987	0.013442	- 4.834466	0.000044
TDTA T0	- 0.128955	0.081390	- 1.584411	0.124331

Conclusion

This research was constrained by several limitations and the regression analysis were performed to lay out the foundation for the next steps of the study, with the objective to define a set of variables that would need

further investigation in a more elaborated model. The results of the regression need to be analysed with care as no additional tests were performed to verify the linearity and normality assumptions. Furthermore, no causal relationship can be established at the moment as all the assumptions for causality were not met by the model.

The results of the paired sample t test for means for R&D intensity suggests that there is no empirical evidence verifying that pharmaceutical M&A activity has reduced innovative output. However, the results of the second paired sample t test suggest that R&D intensity growth decreases significantly prior to an M&A event before increasing substantially after it. This effect was verified in the EU Industrial R&D investment scoreboard published by the European commission in 2016. The results of our findings point towards similar conclusions as the established literature on the topic as we can't explain any causal link between M&A and R&D intensity.

This paper provides an opportunity for the employees of Deloitte to improve and enhance the scope of this study and answer to the research proposed by the European commission by suggesting the use of significant variables as Tobin's Q, EBITDA margin and Total Debt to Total Assets as predictors to explain new pipeline progress indicator variables.

To conclude, suggestions for further analyse would be to investigate the effect of the independent variables used in this model with the different pipeline progress indicators enumerated on Table 2 of the research. Furthermore, by increasing the sample size, further studies could separate the sample into different categories based on their size, reason behind the M&A event ;and the type of M&A activity in which they were involved (e.g.: Asset transactions, acquisition , merger, etc...); to analyse the causal relationship between the different variables. Likewise, the use of a Principal component Analysis (PCA) would be of interest in order to understand which of the predictor variables (i.e. innovation determinants) are truly important and need to be included in the final model. This type of analysis would allow to identify the innovation indicators and variables that have similar predictive or explanatory power.

Limitations

Even though this research gives a contribution to Deloitte for further investigation, the following limitations should be recognized and discussed. The sample is limited to 32 publicly listed pharmaceutical company and therefore does not represent the entire spectrum of the industry. Furthermore, the scope of the research limited our access to payable database and restricted our access to databases on pipeline progress indicators such as patents. In turn, R&D intensity was used a unique innovation indicator limiting the scope of the study.

Finally, the model does not account for time effect and the presence of dynamic relationship. This implies that a change in variable can have an impact on itself or other variables in one or future time periods. Indeed, M&A activity might not have an instantly effect on research intensity, it can be spread or distributed over future time periods that were not represented in the regression.

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Appendix

Case study 1: Novartis/GSK asset swap

In 2014 Novartis and GSK went through a 3 way merger resulting in a swap of assets and pipeline products making both companies more focused in different markets. GSK acquired almost the full global human vaccine business of Novartis, excluding only their influenza departments, and a majority stake in a Joint Venture consisting of both GSKs and Novartis' consumer health businesses. On the majority of the vaccine portfolio the European commission did not have major concerns except for the meningitis vaccine worldwide and the diphtheria/tetanus vaccines in Germany and Italy. This because for the meningitis vaccine market the only market players were Novartis (with Menveo) and GSK (with Mencevax and Nimenrix). This meant that the merger would result in a de-facto monopoly situation. This has been solved by the worldwide divestment of the Mencevax and Nimenrix brands. In the diphtheria/tetanus vaccines the combined firm would have too much market power and they agreed with the commission that GSK should have a 10 year exclusive supply agreement with Germany and Italy. Regarding the oncology portfolio, consisting of 10 launched products and 2 pipeline products, the main problem was regarding the combination of B-Raf and MEK inhibitors in the pipeline. The merger would mean that there would only be 2 players left on the market owning both the B-Raf and MEK inhibitors, reducing the incentive for Novartis to continue development of these products. The commission judged this threat to be credible and that is why they had to transfer both pipeline products to Array biopharma.

The reason that this case study is interesting from an innovation perspective has to do with the phase 2 pipeline products of Novartis that had to be brought back to Array biopharma, it is a case in which the Commission explicitly focused on the phase 2 products in the pipeline and expressed worry of too little incentive to keep innovating. It will be interesting to find out whether the proposed measures have been enough to ensure no significant impediment on innovation in these markets.

Case study 2: M.2922-Pfizer/ Pharmacia

In 2003 Pfizer acquired Pharmacia for 60 billion dollars, which made the combined entity the largest pharmaceutical firm in the world with an overall market share of 11% and 48 billion dollars in annual revenues. Pharmacia was engaged in R&D, production and sales of human pharmaceutical products, consumer health products, fine chemicals and animal healthcare. Consequently, the parties had horizontally overlapping activities in human pharmaceuticals, active substances and animal healthcare.

The Merger was a way for Pfizer to fill its product pipeline. Indeed, through the merger Pfizer's late-stage pipeline was boosted by pharmacia's drugs including investigational compound eplerenone, parecoxib and CDP-870.[24] Three markets in human pharmaceuticals were identified by the European commission where there were certain competition concerns. In order to eliminate these concerns both merging entities had to divest part of their assets.

Concerning the market for C2A antihypertensive plain in the Netherlands, the merged entities would have made a big part of the market share as both companies were already the market leaders in that country. The parties offered to stop selling Kentensin and transfer its rights and assets to a third party in order to avoid competition concerns.

This case study is of interest as it involves a mega merger between two giants active in the pharmaceutical industry, where the main argument for the merge was to fill the pipeline of the bigger company and not necessarily to obtain synergies from the knowledge available in the smaller firm. The deal did require some divestment of assets and compounds as a result of competition concerns raised by the European commission.

[24] Ocular Surgery News US edition. (2002, August 15). Pfizer and Pharmacia announce plans to merge. Retrieved from https://www.healio.com/ophthalmology/news/print/ocular-surgery-news/%7Bc03134fd-0bd6-4bbd-872f-0b8d646c45bf%7D/pfizer-and-pharmacia-announce-plans-to-merge

Case study 3: Acquisition of Hospira by Pfizer

In 2015, Pfizer acquired Hospira for 17 billion dollars. The acquired company, an American biomedical pharmaceutical company, specialized in injectable drugs and infusion technologies as well as being a global leader in biosimilar medicines. Pfizer's motive behind the merger was to obtain the knowledge from Hospira and with it become the global leader in the sterile injectables drugs, biosmilars and infusion technology. Biosimilars are a lower cost alternative to biological medicines as they are approved by the FDA and have no significant clinical difference from their reference product. However, they are different from generics in the sense that they can never be exactly the same as the reference drug and are significantly more expensive to be produced.

Infliximab, one of the bestselling medicine in the world, had a biosimilar co-marketed by Hospira in the EEA. Pfizer was also developing a biosimilar of infliximab before the merger that was in the late stage of development. The European commission found it very plausible that the merger between the two companies would have led to a decrease in competition due to the cancellation of its own infliximab biosimilar development.

In order for the merger to be approved by the European Commission, Pfizer had to divest two of its activities. The approval was conditional to the divestment of some of Pfizer sterile injectable drugs and one of its compound in the development stage, the infliximab biosimilar drug.

In this case it will be interesting to see whether the merger provided Pfizer with enough knowledge to gain synergies in its pipeline and innovate their way to become the global leader in the sterile injectable drugs, biosmilars and infusion technology. Additionally, Pfizer had to divest its late stage infliximab biosimilar, it will be interesting what effect that had on other players in the competitive environment and whether it fueled innovation.

Case study 4: Sanofi Aventis –Genzyme merger

In 2011, Sanofi-Aventis proceeded to the acquisition of the US biotechnology firm: Genzyme Corporation. The combination of both companies contributed to Sanofi- Aventis' growth strategy by expanding its presence in biotechnology. The acquisition gave Sanofi access to Genzyme's capabilities in treating renal endocrinology, Hematology-Oncology and Biosurgery business that are complementary to Sanofi-aventis existing business. After this deal Sanofi's entire oncology research department was moved to the research center in Cambridge. The deal was worth 20 billion dollars plus an additional contingent value right (CVR) for Genzyme's old shareholders.

This case is of interest, as suspicions exist that Sanofi Aventis, on purpose, did not invest enough resources and delayed the FDA approval of Genzyme's late stage compound fighting multiple sclerosis drug: Lematrada. The CVR agreement was based on Lematrada gaining FDA approval as well reaching future sales volume. Genzyme's former shareholders filed a claim suing Sanofi for delaying the development and promotion of Lematrada in order to avoid paying CVR rights. Investors claimed that Sanofi preferred to develop and promote Aubagio, Sanofi's in house developed multiple sclerosis drug and made no diligent efforts to achieve the different milestones set in the CVR agreement.

Hence, it will be interesting to see whether the financial structure of the deal put a break on innovation or whether the effect was only minor. Additionally the moving of its entire cancer research into Genzyme's research center in Cambridge could have had a positive impact (through synergies) and a negative impact (due to the impact on the continuation of research) on innovation. It will be interesting to explore this.